GSFC

Codes
582&588

Demonstrating a Realistic IP Mission Prototype

A collaborative task between Flight Software Branch Code 582 and Advanced Architectures and Automation Branch Code 588

FY 2002

Introduction

- IP-in-Space program started in 1998 with Code 588 and funding from SOMO
- FY02 funding by ESTO
- GPM Participation
- Relevance to CANDOS, Ground & Space Networks

Team Members

- Project management -- Jim Rash (PI) & Art Ferrer (Co-I)
- Code 582 -- Joe Polk, Lorin Johnson, Greg Menke, Bill Miller, Nancy Goodman, Samira Ghazi-Tehrani
- Code 588 -- Keith Hogie, Frank Hallahan, Ed Criscuolo, Ron Parise

Objectives

- Examine integration of COTS technology/products into flight environment
- End-to-end automated data flows using “realistic” hardware, software, and environment in the lab
- IP mission concept implemented in lab

Demonstrated Functions

- COTS products integrated in to Flight Software Environment
  - Triana mission flight software architecture
  - Multicast Dissemination Protocol
  - Network Time Protocol (between space, ground and time server)
  - RTLinux
  - IP Space to Ground interface
- Added Communications Link simulation
- Added Ground Support Environment
- Encapsulated CCSDS packets in TCP/IP packets for spacecraft command and telemetry.
- On-board LAN architecture (instrument, C&DH processor)
- Real time commanding and telemetry data return
- Science data return using MDP
- On-board clock sync using NTP

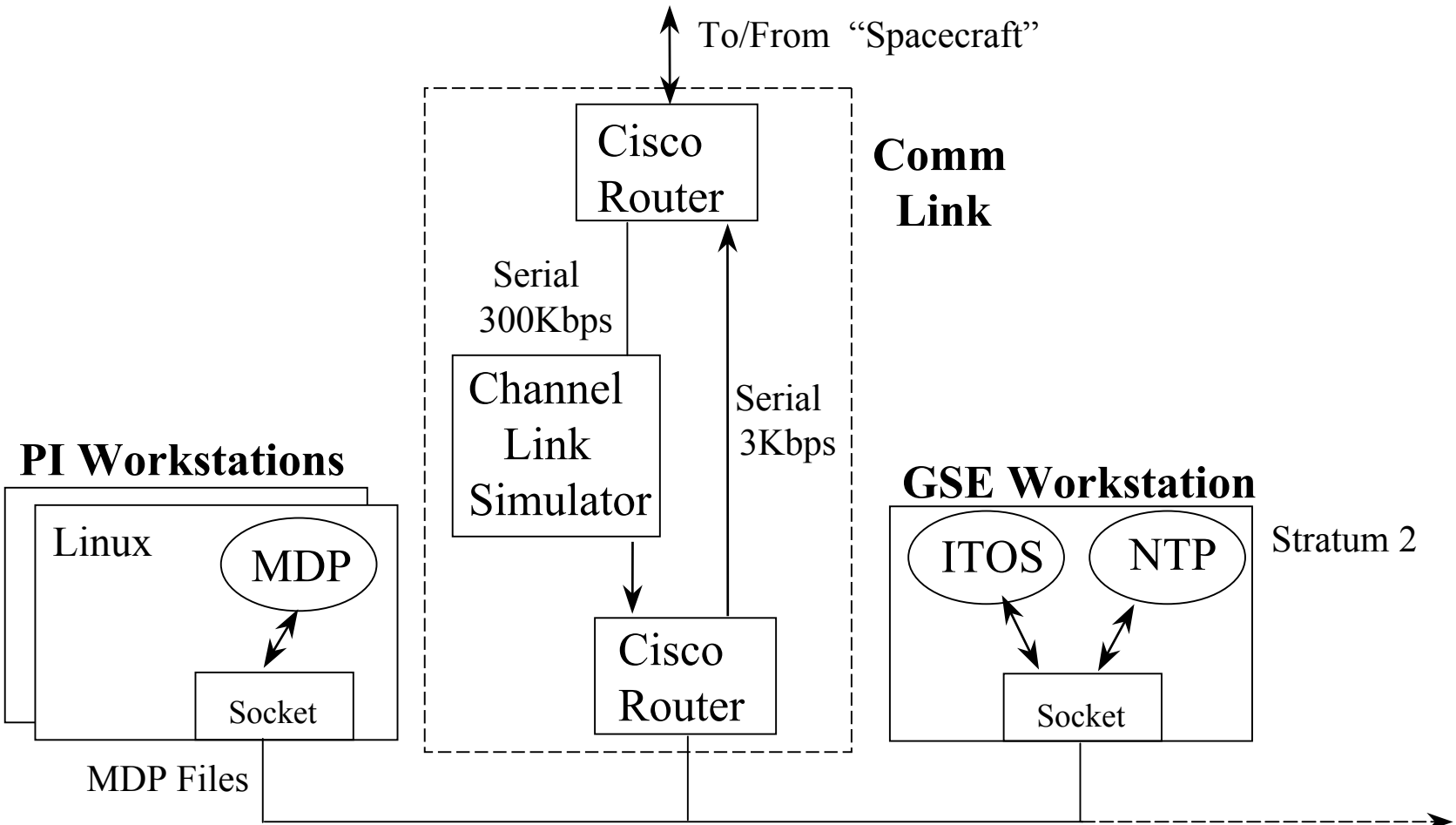
Multicast Dissemination Protocol

- Developed for heterogeneous networks and wireless applications,
- Automated multicast file transfer (one-to-many, many-to-many) and uni-cast capability over UDP/IP.
- Reliable NACK oriented file transfer
- Fielded product used by USPS and US Army.
- C++ application
- MDP lessons learned migrating to IETF work on NACK Oriented Reliable Multicast (NORM)

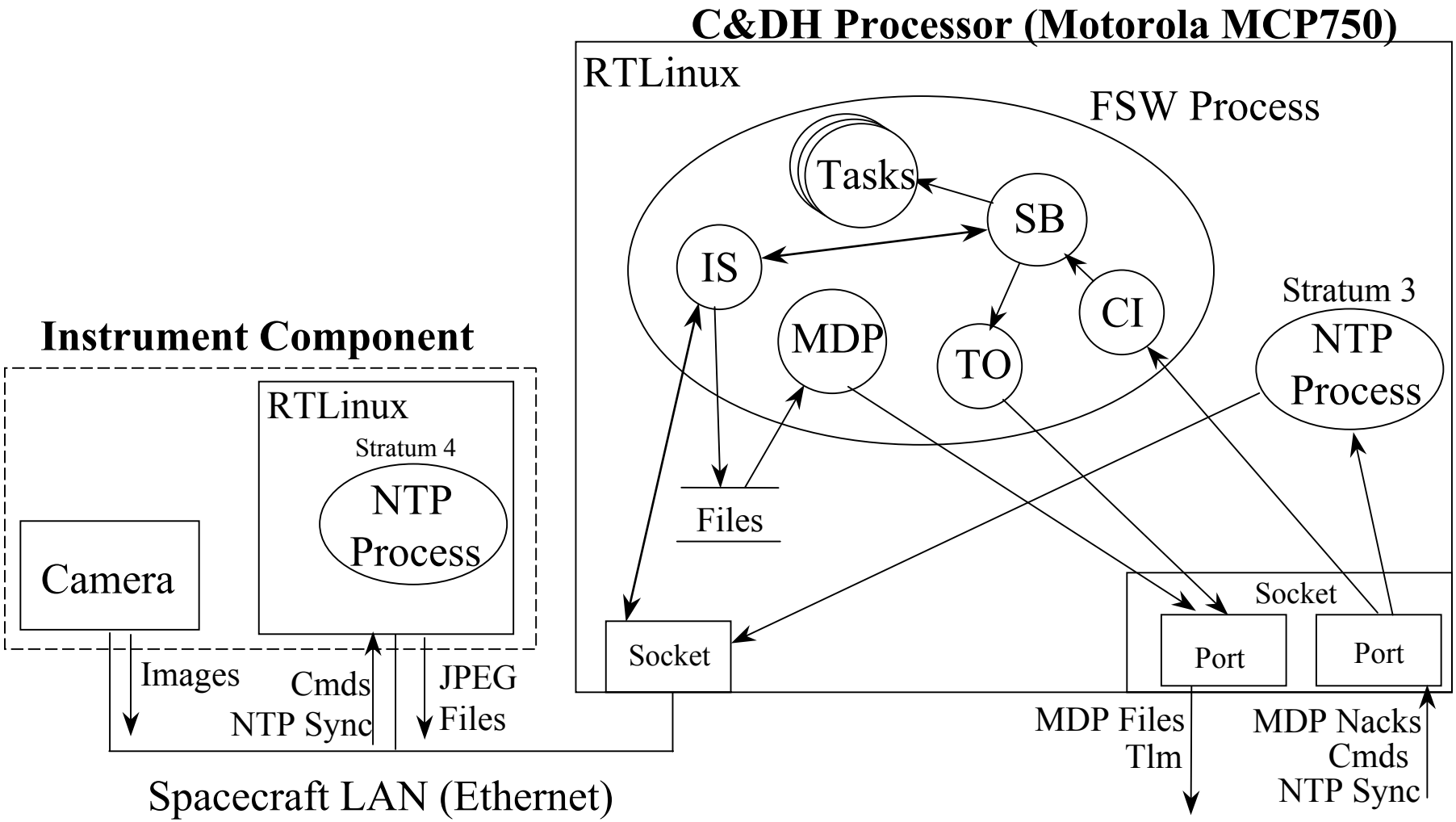
Network Time Protocol

- Developed to synchronize time of a computer client or server to another server or reference time source
- Millisecond accuracy or better
- Can use multiple time references
- Authentication
- Open Source

"Ground Segment/Comm Link "



"Spacecraft Component"



Triana FSW Baseline

- Triana mission flight software architecture
  - C++ object oriented, modular design
  - priority based multitasking system
  - existing Command & Telemetry GSE database
  - CCSDS packet based communications
- Linux port of VxWorks based FSW
- Ported key Triana flight software Command & Telemetry components to RTLinux on MCP750

Effort Overview

- MDP added as thread component of flight software process
  - Server retrieves (JPEG) files from “hot” directory and forwards files to client automatically
- NTP added as separate process
- Purchased MDP and NTP upgrades to the Real Time Embedded Multiprocessor System (RTEMS)
  - RTEMS is flight Real Time Operating System (RTOS) for ST5

Effort Overview

- Added ITOS/GSE component
  - Instrument commands/telemetry database
  - Procedures
  - Telemetry display page
- Added instrument component for JPEG image data files
- Added serial uplink/downlink component
  - Router Ethernet/Serial interfaces
  - Channel link simulator for delay and error injection
- Implemented multicast file distribution (MDP, router, multiple PI workstations)
- Implemented NTP synchronization among space, ground system, and NASA time server

Summary

- Demonstrated automated data flows representing mission operations scenarios on “realistic” hardware and software that implements the IP mission concept in the lab
- Concurrence that on-board networks are ripe for further investigation
- Discretion must be used for selecting COTS products for flight use. Consider the following:
  - Unused capability implies dead code
  - Custom flight hardware interfaces
  - Maintenance concerns (in-flight patching, technical support)
  - Availability of appropriate Real Time Operating Systems (RTOSs) on flight hardware
  - Resource limitations in flight environment (memory, EEPROM, limited flight processor selections)

Influence on the GPM Mission

- Global Precipitation Measurement (GPM) Mission has baselined the following:
  - IP Space to Ground communications (w/ HDLC framing)
  - Onboard Ethernet network
  - File transfer protocol
- Technical Work in progress
  - Flight processor selection
  - Ethernet drivers and Real-Time Operating System selection
  - Flight hardware (Comm card, Ethernet cards and switch)
  - TCP commanding to be replaced with reliable mechanism over UDP (CCSDS COP-1 capabilities)
  - CCSDS File Delivery Protocol (CFDP) recommendation based on trade study between MDP and CFDP.

Future Work

- RTOS and device driver availability for flight hardware
- RTOS with TCP/SSH/TELNET functions
- Hard real-time performance characterization of network stacks
  - Performance testing of industry LAN-based real-time technologies
- LAN failover/recovery and bandwidth reservation
- Investigation of NTP for time management
- Reliable multicast data transfer using NORM
- Higher data rate technologies
  - Framing standards (HDLC, ATM, DVB)
  - COTS ground equipment (Ka band 1.2 Gb rates)